Throughout the simulations, the above plots are generated for each of the two systems. Since the systems are identical in configuration, due to symmetry of their geometrical layout, their performance should be identical as well. However, this happens only if the simulations are run for a time sufficient for the results convergence. Presenting results for both systems demonstrates that the convergence is achieved.

6.1 *Simulation Case 1: Cross-Country Scenario with 40% Spectrum Overlap*

In the first simulation case, a typical cross-country scenario is considered. For this case, base stations of both systems are configured as omni-directional. The patterns of the utilized antennas are presented in Fig. 14. As seen, the main beam of the vertical pattern is up-tilted by 4 degrees. Additionally, the vertical pattern has a 'null fill', which is typical for almost all commercially used omni directional antennas. The vertical pattern exists only for the elevation angles between –90 and 90 degrees. Through simulations, the loading scenarios of 25%, 50% and 75% relative to the pole point are considered. According to the calculations presented in Section 4, at the pole point capacity each omni-directional cell serves approximately four aircraft. Therefore, different levels of network loading can be characterized with an appropriate number of aircraft flown over the market area. The mapping between the number of aircraft served per system and the loading relative to the pole point is presented in Table 3. The number of aircraft is specified for the entire system. To obtain the average number of aircraft per cell, divide second column of Table 3 by 4. Each aircraft has ten voice calls in place.

Table 3. Mapping between loading and the total number of aircraft per system – omni-directional cross-country scenario

Loading [%]	Number of aircraft per system
25	4
50	8
75	12

Simulation results for the three loading cases are presented in Figs 15-25.

Intuitively, the best indication of the cross system interference can be obtained by analyzing Figs 15, 18 and 21. These figures present time domain degradation of the forward link SINR. As one might expect, with an increase in traffic load, the level of the cross-system interference increases as well. This happens for two reasons. First, as the loading is increased, the number of aircraft within the market becomes larger. This makes the airspace above the market area more congested and reduces the average distance between aircraft. Secondly, as the loading is increased, the average transmit power on the reverse link becomes larger. With an increase of the reverse link transmit power, the likelihood of interference becomes greater. According to Figs 15, 18 and 21, the degradation of the forward link SINR can exceed 10dB. However, large degradations occur with low probabilities and last for relatively short periods of time. Even in the case of 75% pole point loading, most of the time the degradation of the SINR is smaller than 1dB. Degradation smaller than 1dB may be considered negligible from a practical standpoint.

A better quantitative indication of the forward link degradation can be obtained from Figs 16, 19 and 22. For the sake of easy comparison between different simulation cases, in this report, a

SINR degradation larger than 1dB would be considered significant. From Figs 16 and 19, one sees that in the case of 25% and 50% loading, the probability of experiencing a SINR degradation larger than 1dB is negligible. In the case of 75% loading, significant degradations might be experienced in approximately 0.2% of the time. To prevent capacity problems, it is common engineering practice to sectorize CDMA systems well before they reach the point of 75% loading. Therefore, it is safe to say that in the case of the cross country omni-directional scenario, the probability of experiencing significant SINR degradations is negligible. Numerical probabilities are provided in Table 4.

Table 4. Probability of experiencing SINR degradation larger than 1dB

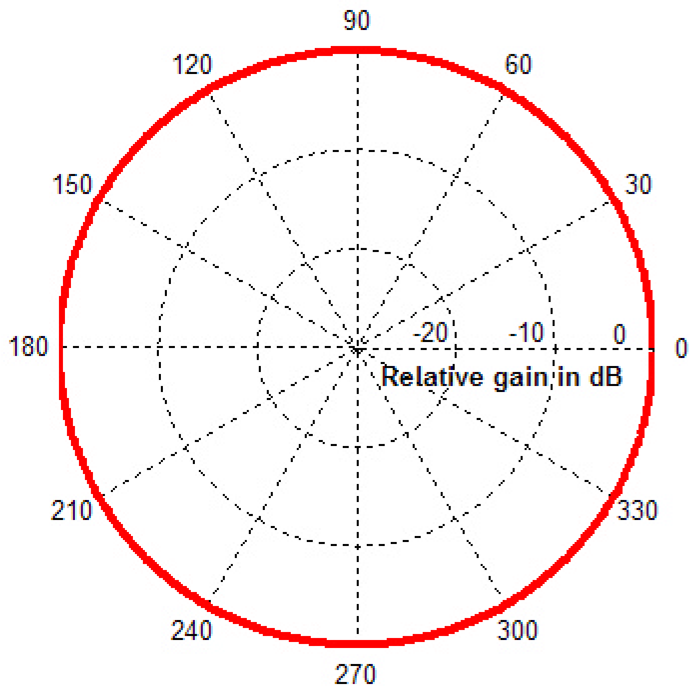
Loading [%]	System 1 [%]	System 2 [%]	Average [%]
25	0	0	0
50	0	0	0
75	0.2	0.15	0.18

The distributions of the reverse link transmit power for the three loading cases are presented in Figs 17, 20 and 23. It is seen that as the network loading increases, the average transmit power becomes larger as well. Additionally, one should notice that as the two systems approach 75% loading, the probability of transmitting at the highest PA power level (23dBm) becomes larger. In CDMA based cellular systems, a mobile should never transmit at the maximum PA power level. When that happens, it usually means that the system is reaching the pole point and that the mobile is struggling to overcome the noise floor increase [3]. When the system is operating in the vicinity of the pole point, the reverse link degrades rapidly. That leads to degradation of the call quality and may ultimately result in dropped calls. The results of the reverse link TX power analyses are summarized in Table 5.

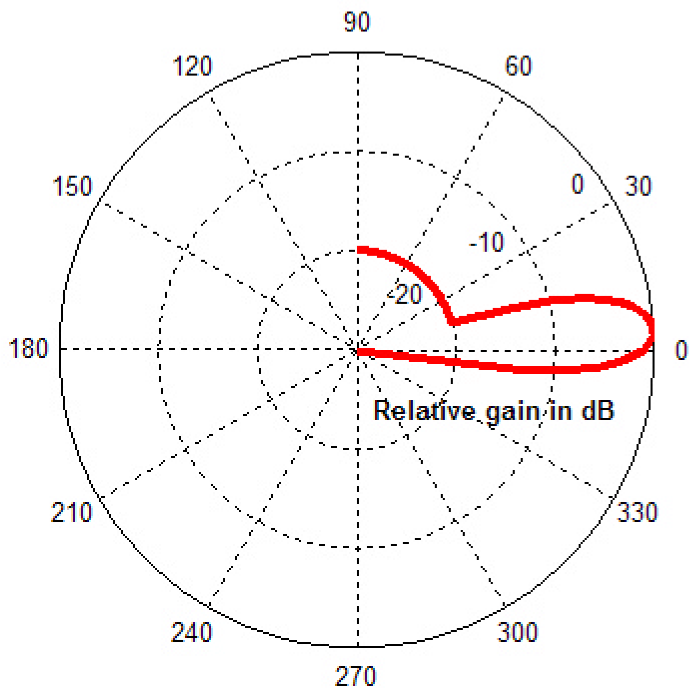
Table 5. Average reverse link TX power

Loading [%]	System 1 - mean TX power [dBm]	System 2 - mean TX power [dBm]	Average TX power [dBm]
25	9.27	9.23	9.25
50	11.40	11.07	11.24
75	15.24	15.48	15.36

The absolute and relative reductions of the forward link throughput in the cross-country case are presented in Fig. 24. As seen, the reductions are very small. In the worst-case scenario of 75% pole point loading, the decrease in the forward link throughput is smaller than 1% of its average value. In a more typical scenario when the loading is below 50%, the cross system interference reduces the average forward link throughput by less than 0.21%. This is indeed a very small reduction and is considered insignificant. Furthermore, in 1xEvDO networks, the reverse link is the limiting one and such a small reduction in the forward link data rate becomes unnoticeable.



Horizontal pattern



Vertical pattern

Figure 14. Horizontal and vertical pattern of the antennas used for the omni-directional configuration of the cell sites. The maximum absolute gain of the antenna is 9dBi.

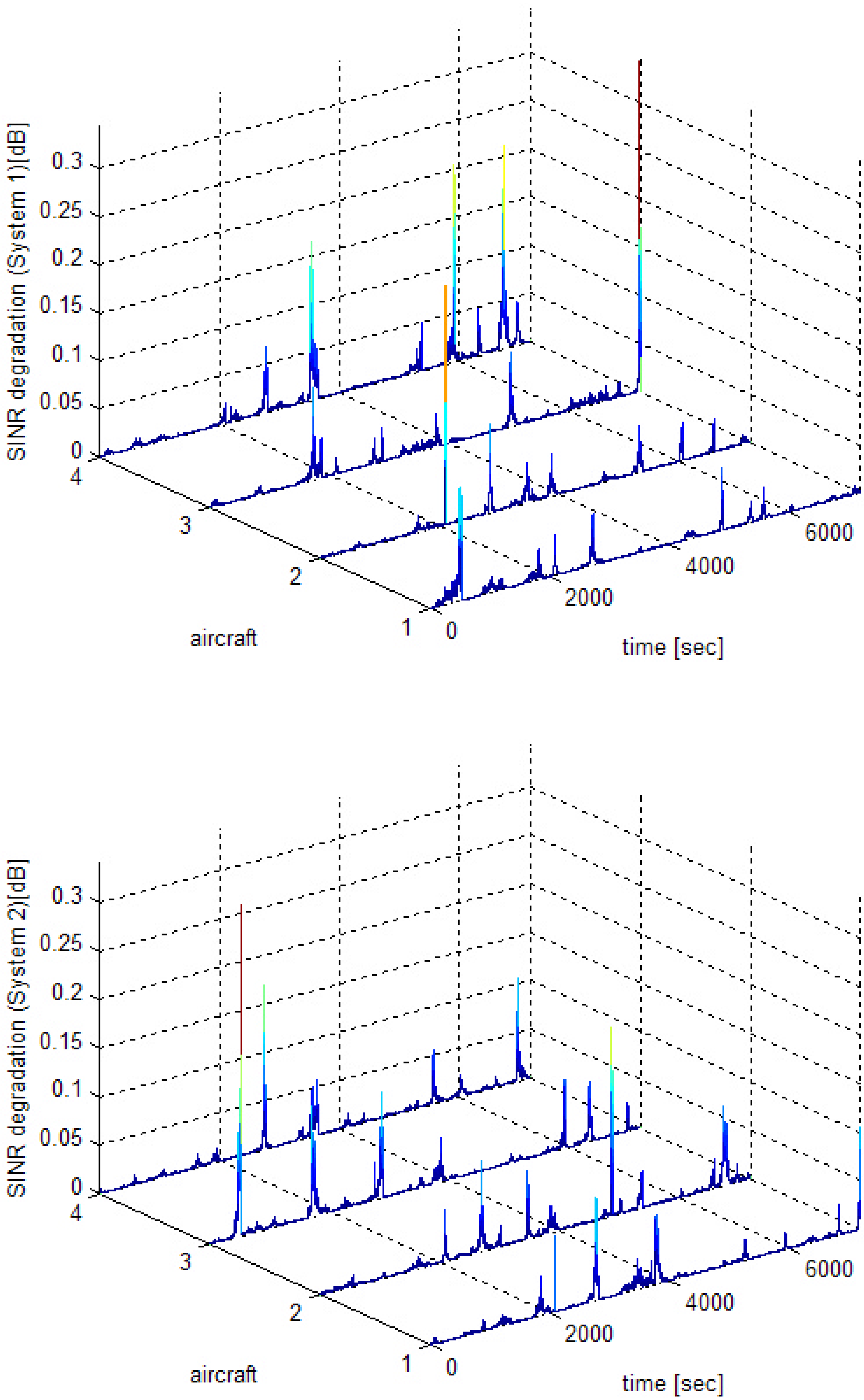
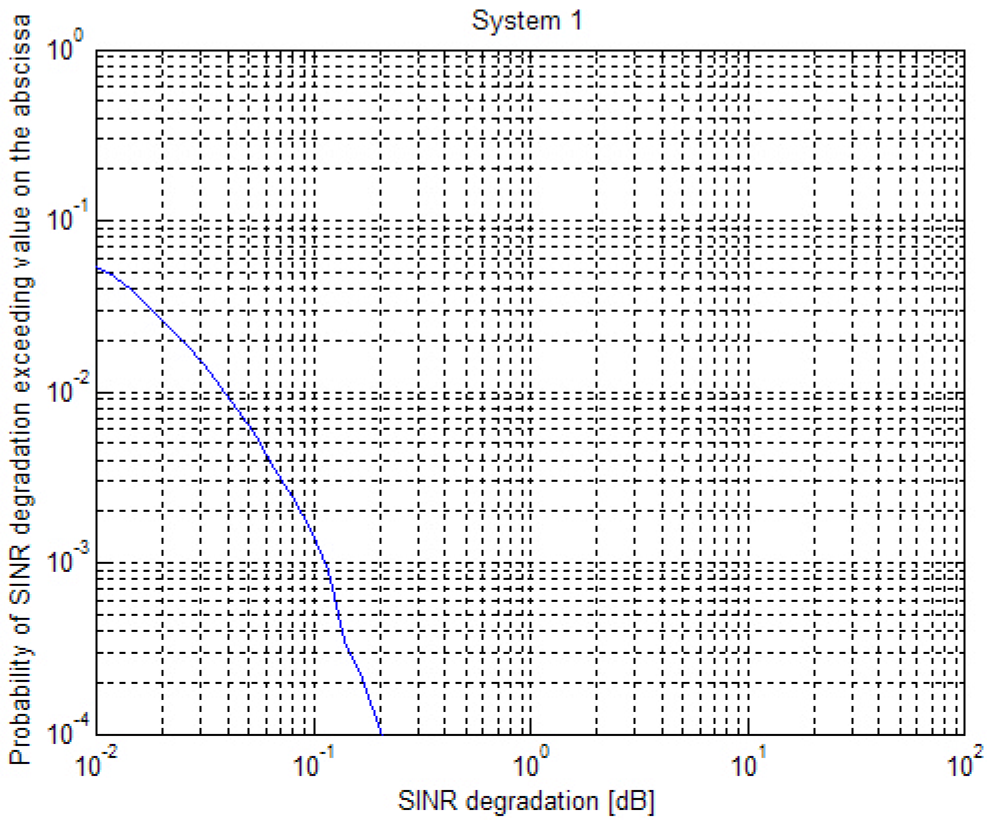


Figure 15. Time domain SINR degradation for cross-country system configuration, 25% pole point loading and 40% spectrum overlap



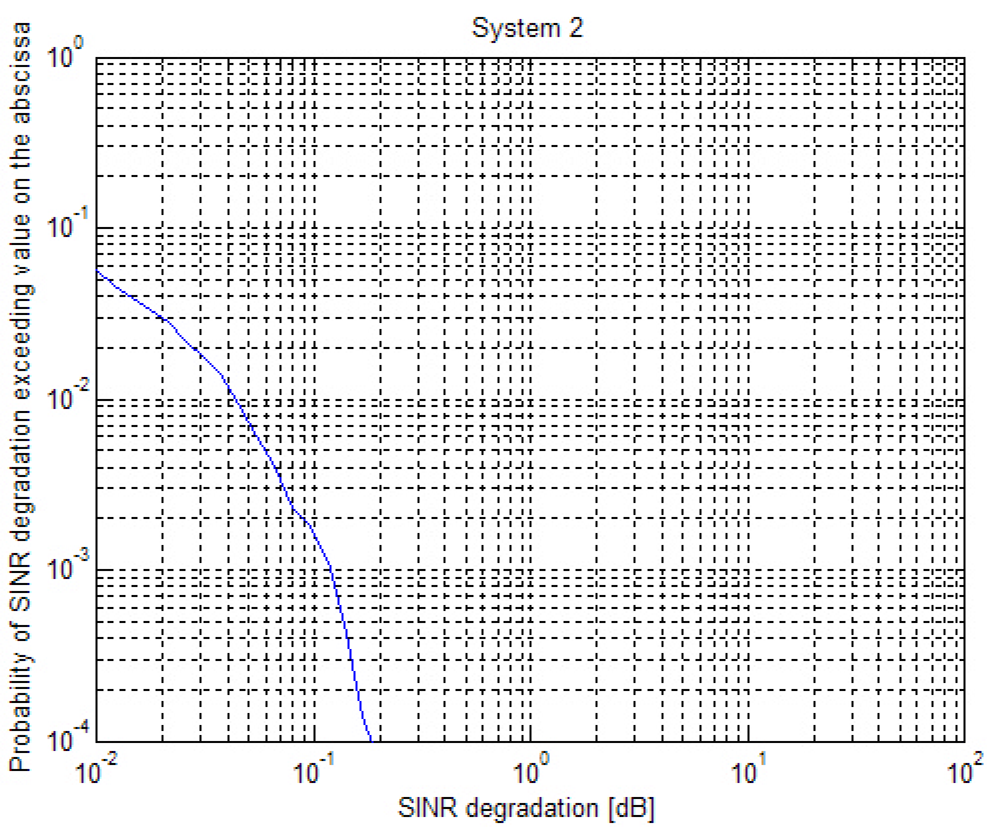


Figure 16. Probability of the SINR degradation for cross-country system configuration, 25% pole point loading and 40% spectrum overlap

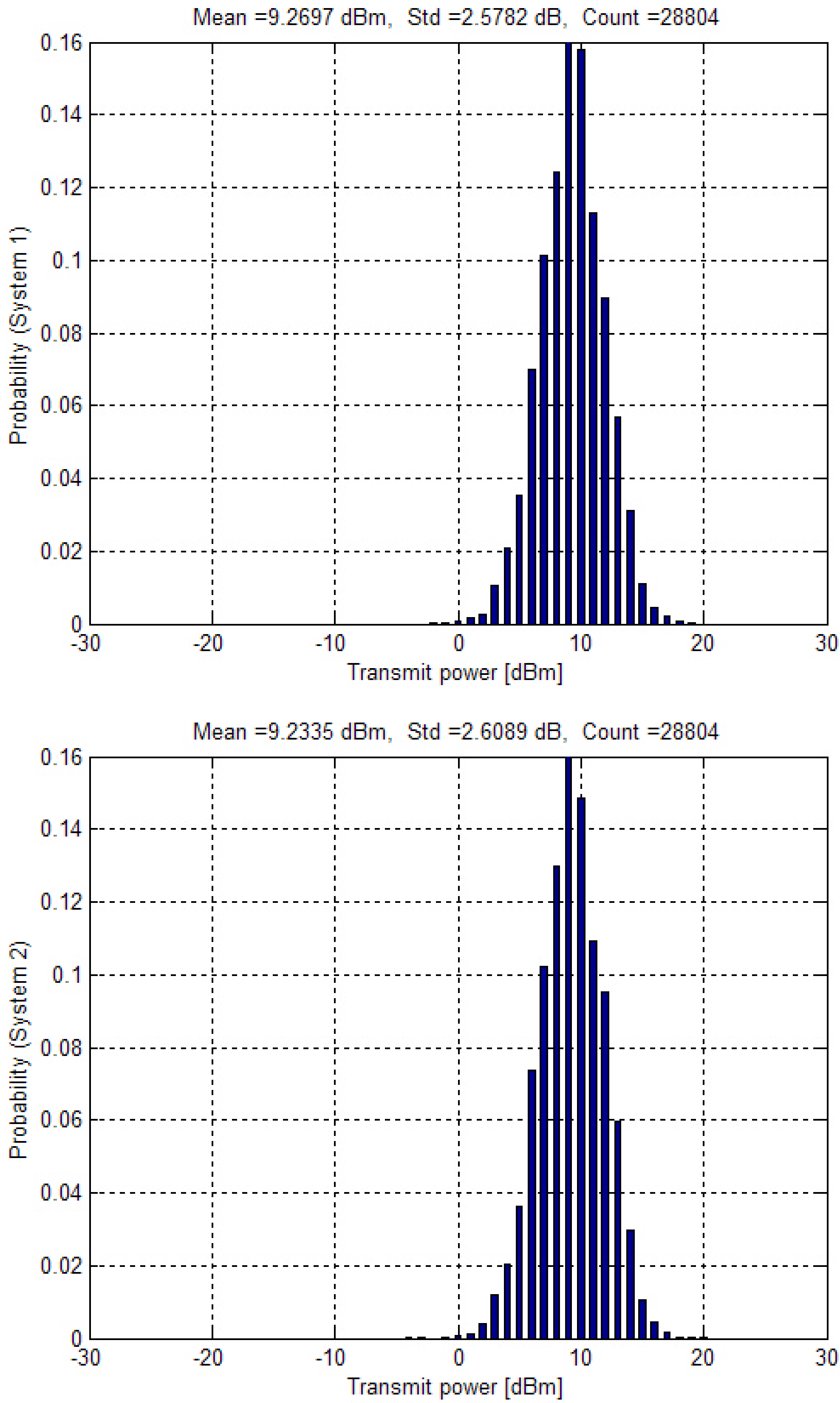


Figure 17. Distribution of the aircraft transmit power for cross-country system configuration, 25% pole point loading and 40% spectrum overlap

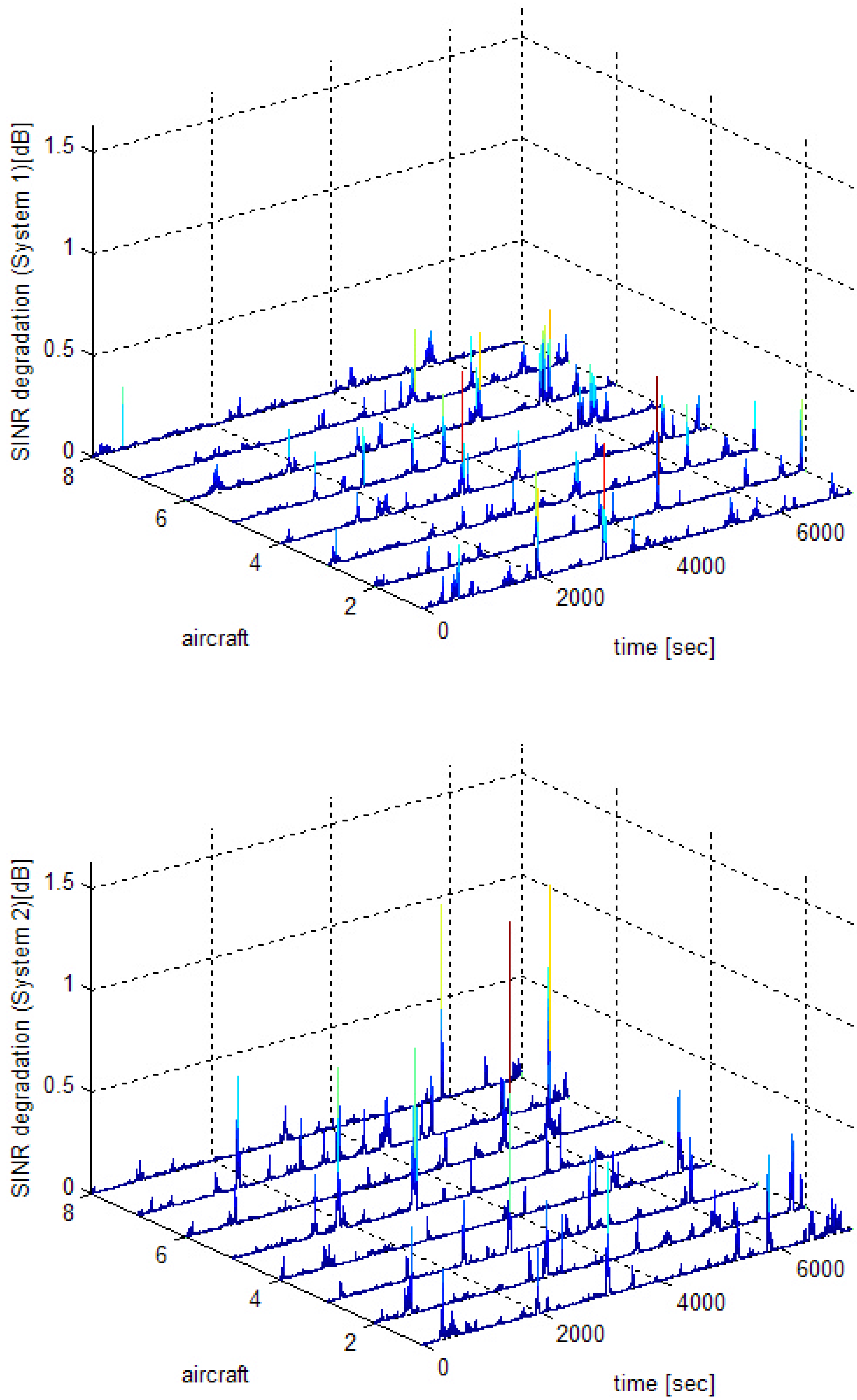
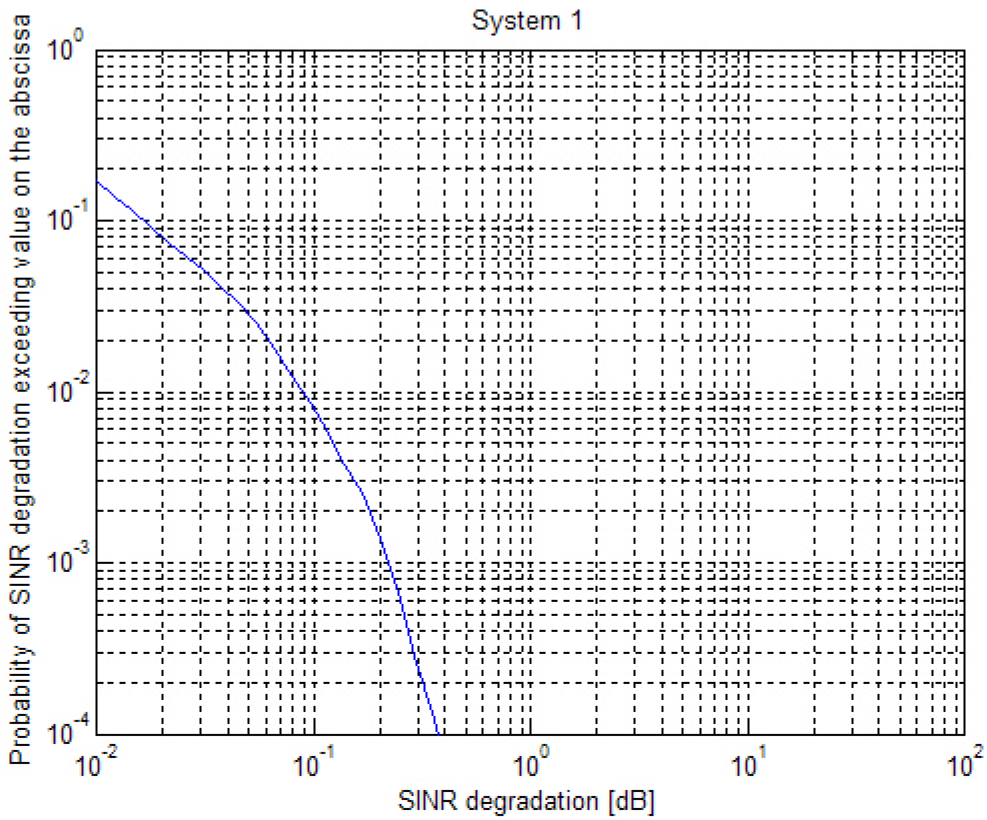


Figure 18. Time domain SINR degradation for cross-country system configuration, 50% pole point loading and 40% spectrum overlap



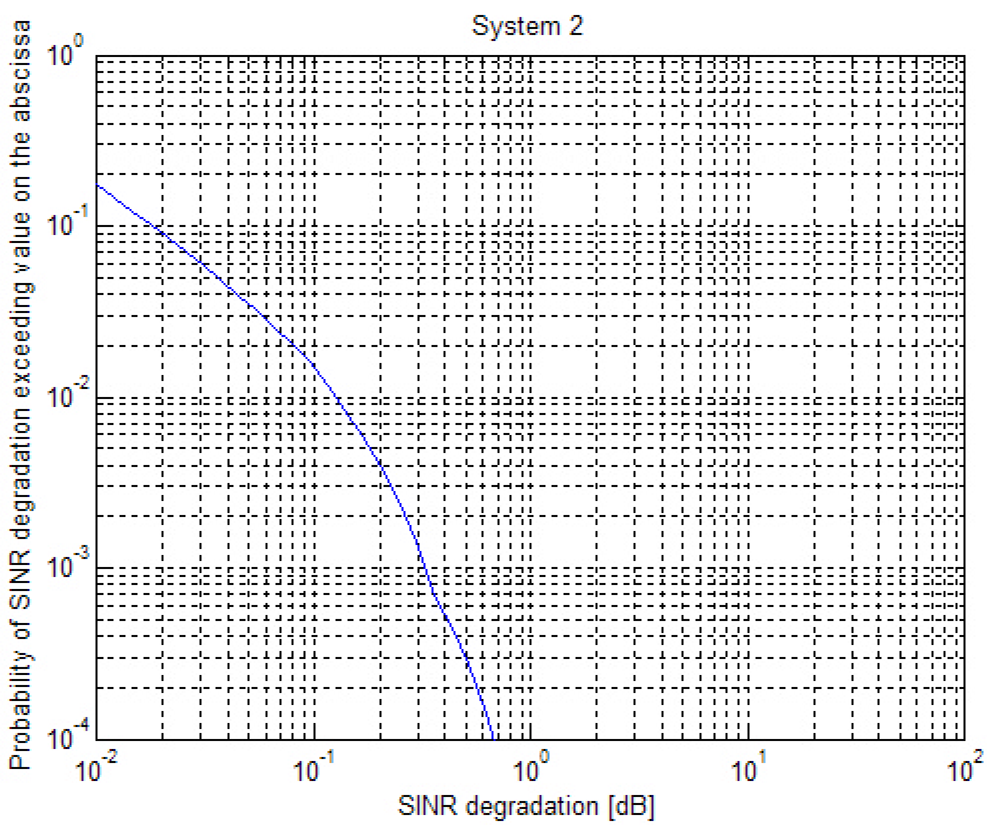


Figure 19. Probability of the SINR degradation for cross-country system configuration, 50% pole point loading and 40% spectrum overlap

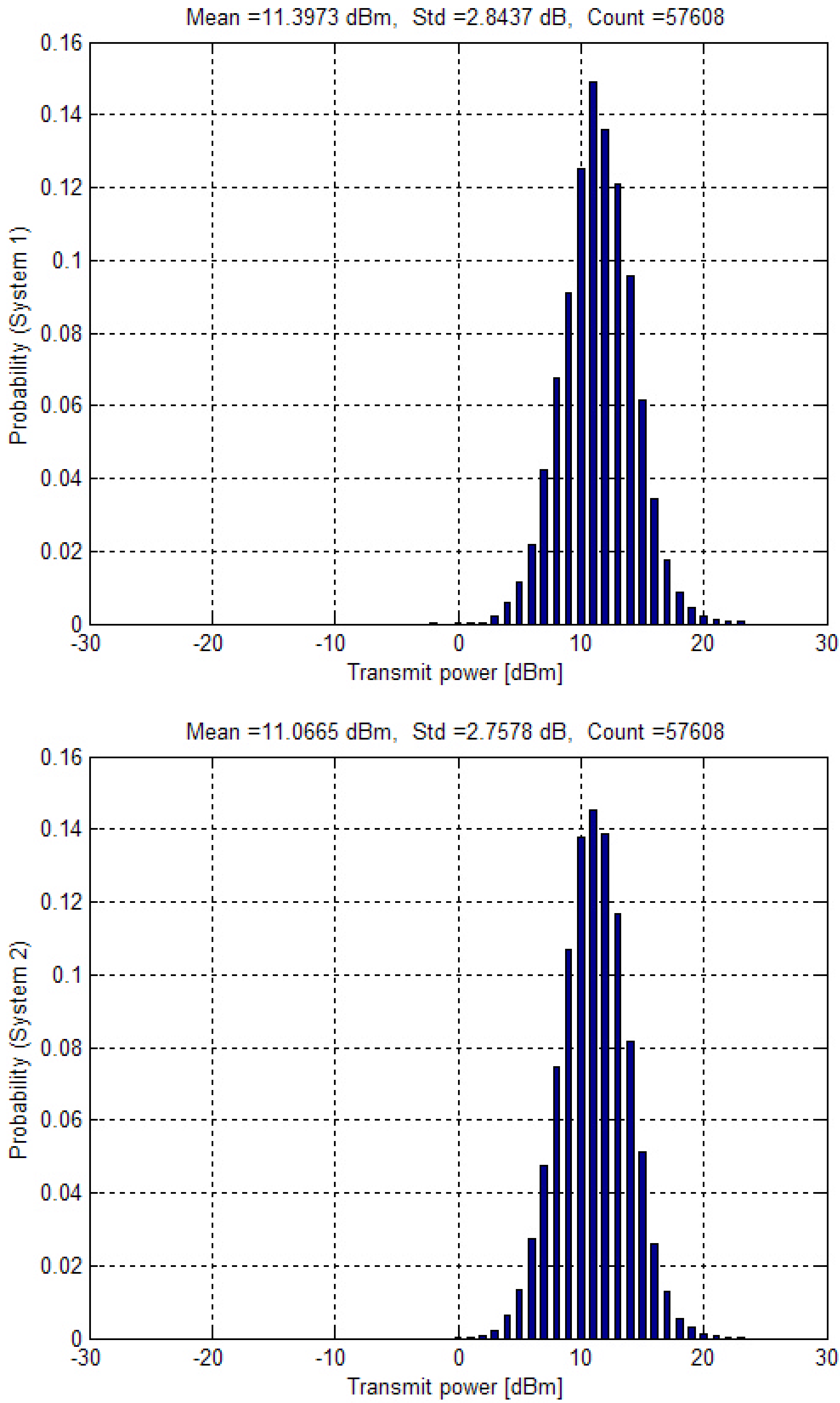
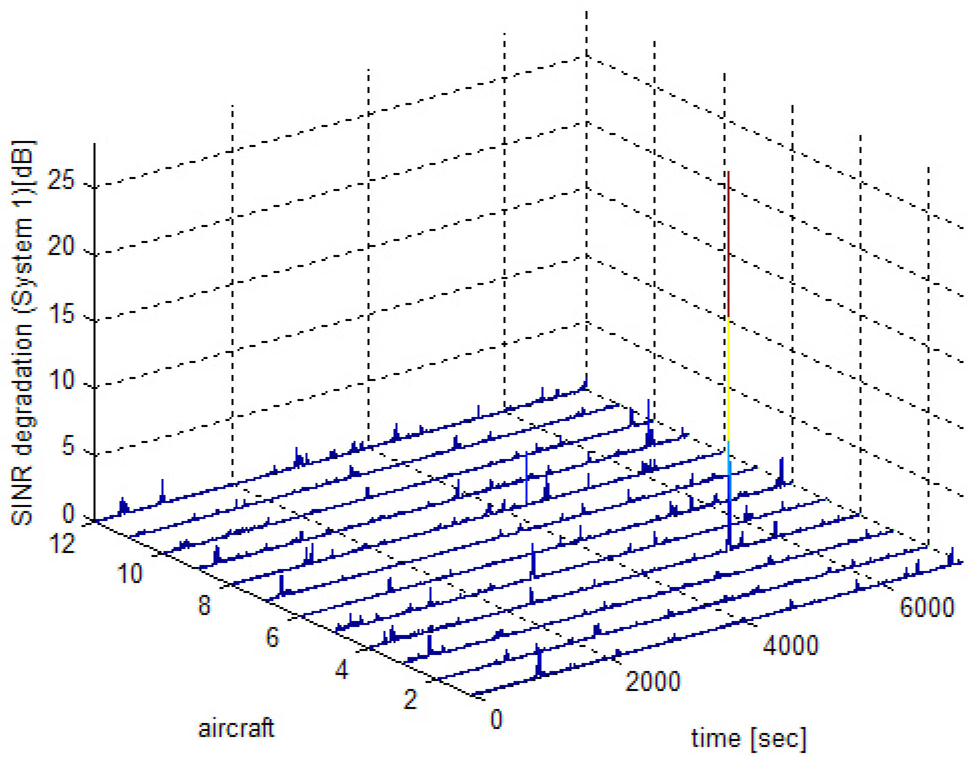


Figure 20. Distribution of the aircraft transmit power for cross-country system configuration, 50% pole point loading and 40% spectrum overlap



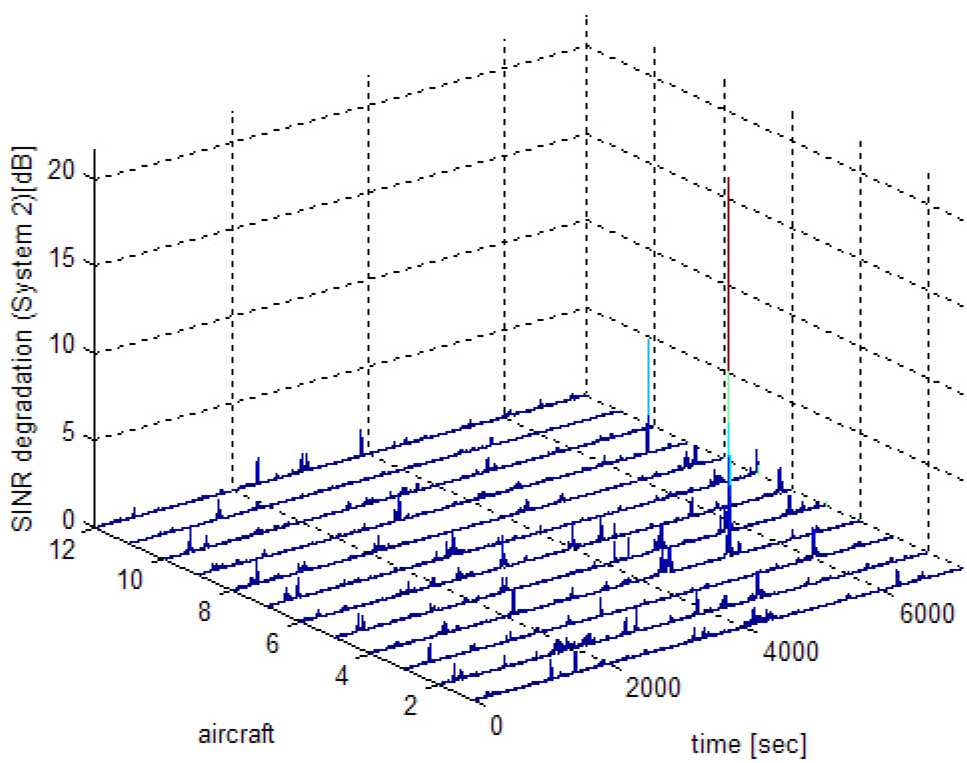
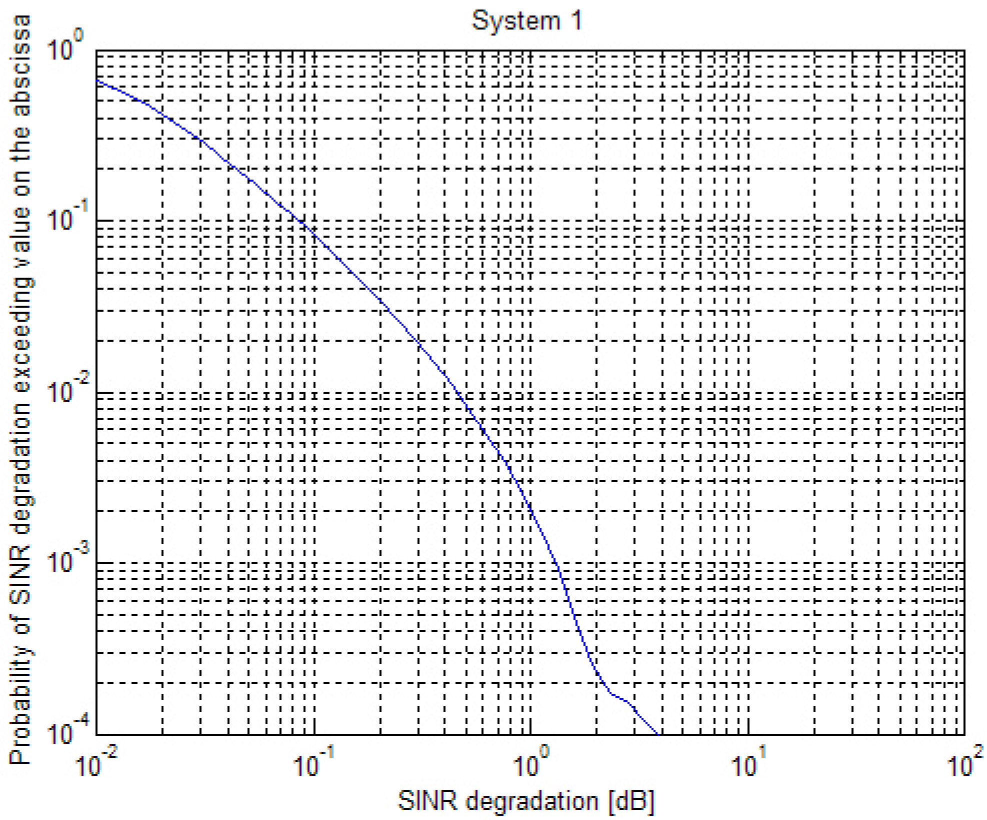


Figure 21. Time domain SINR degradation for cross-country system configuration and 75% pole point loading



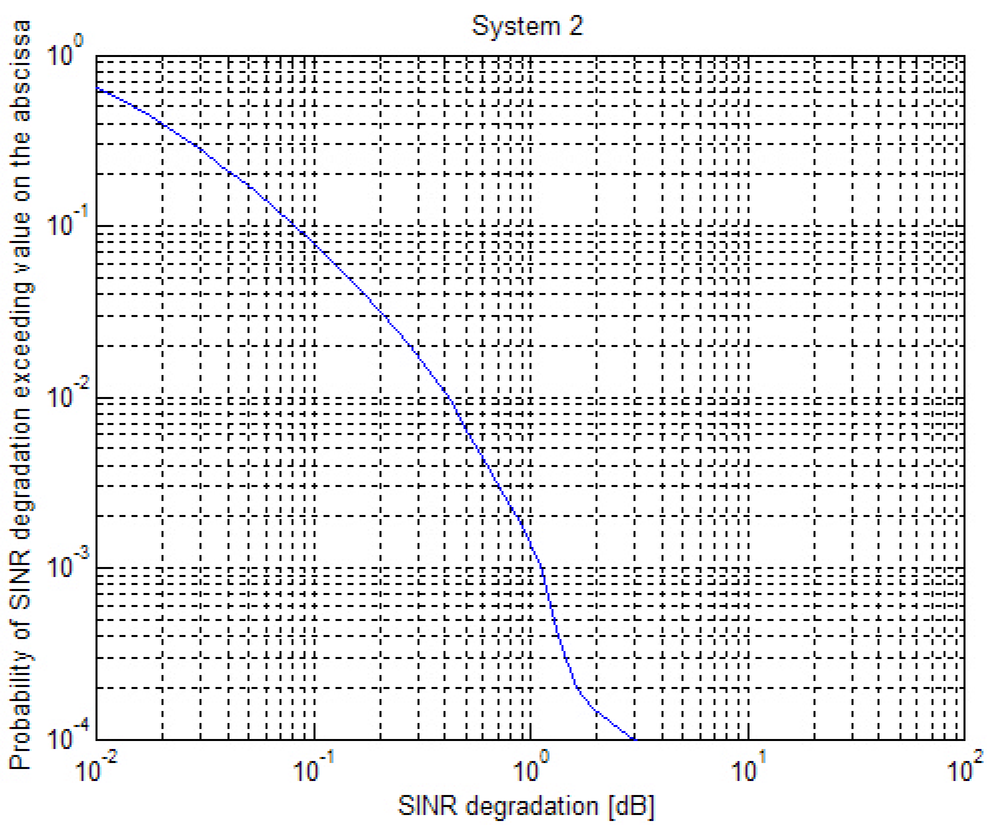
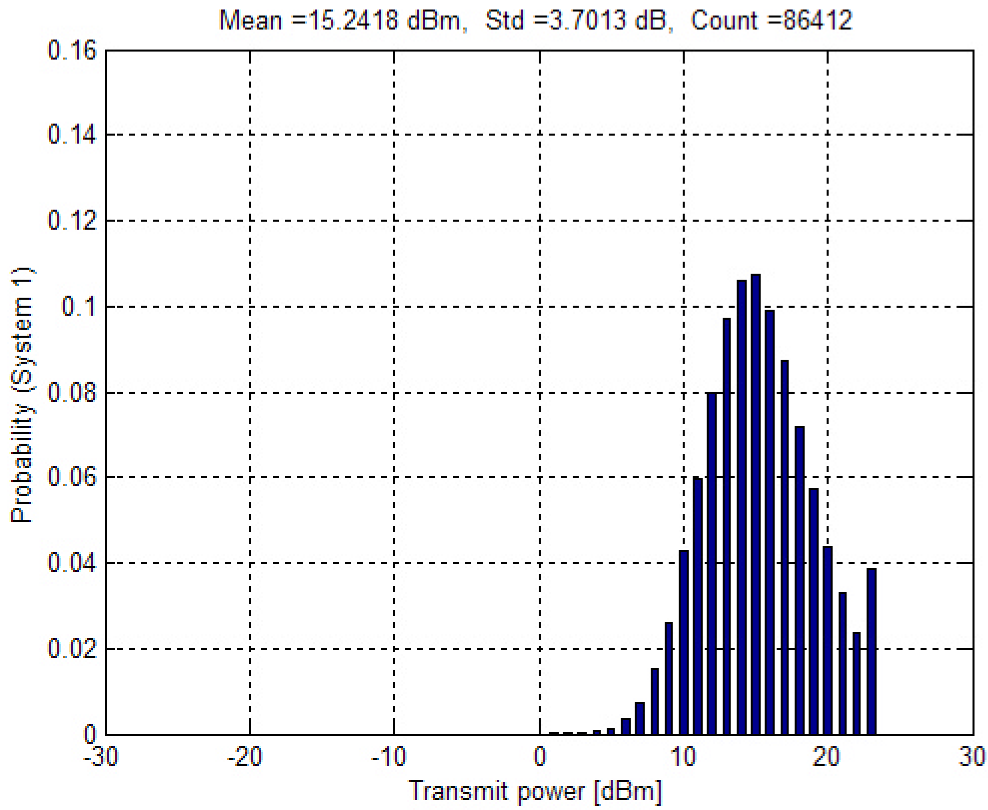


Figure 22. Probability of the SINR degradation for cross-country system configuration, 75% pole point loading and 40% spectrum overlap



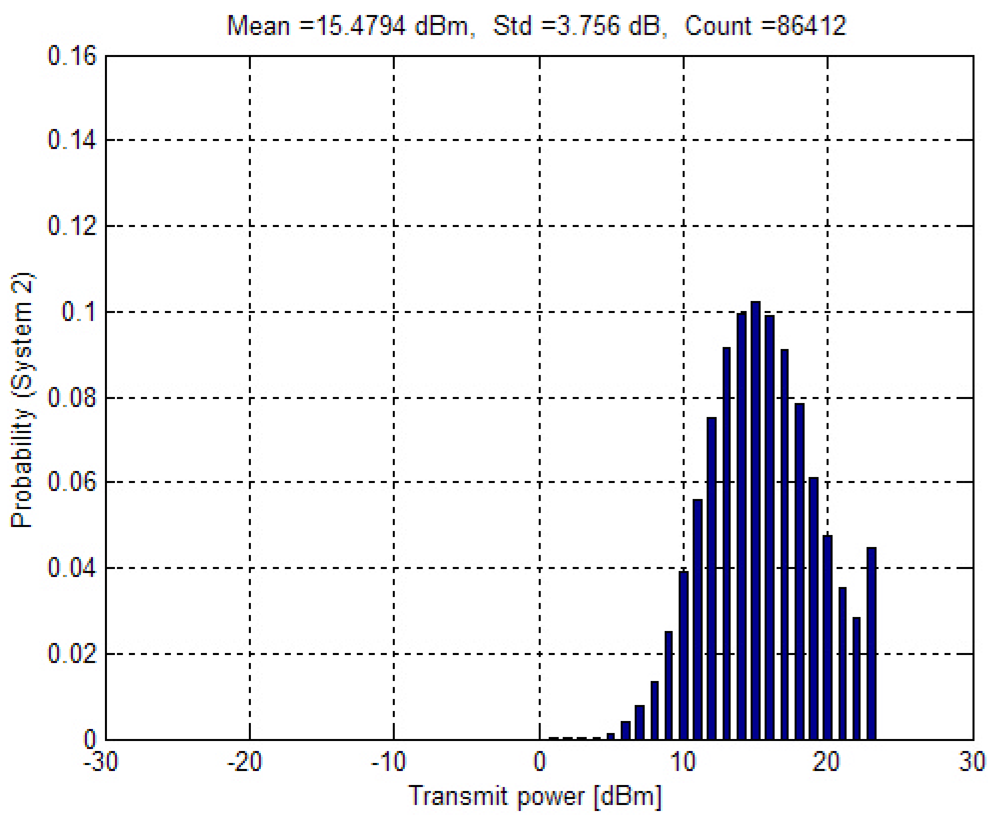


Figure 23. Distribution of the aircraft transmit power for cross-country system configuration, 75% pole point loading and 40% spectrum overlap

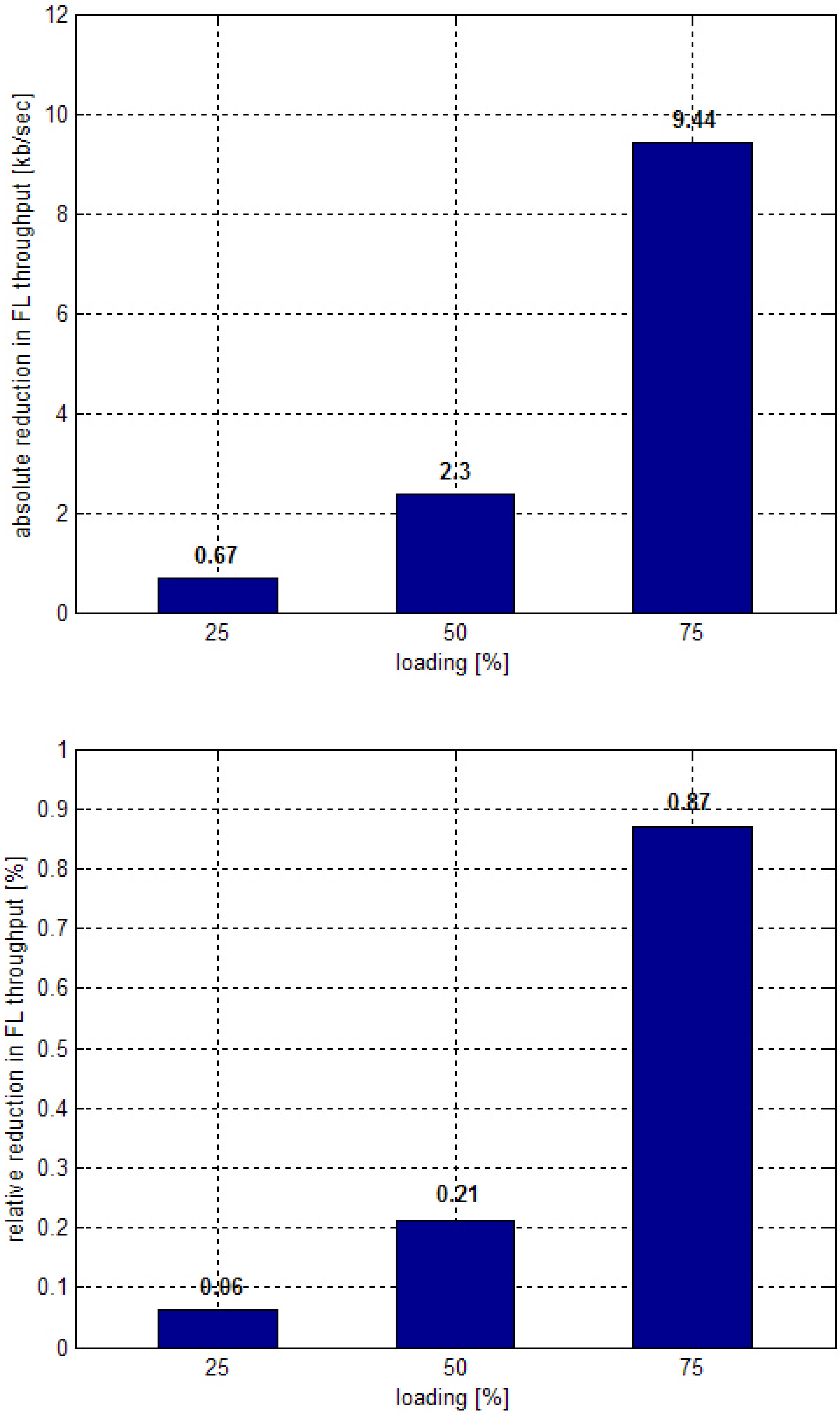


Figure 24. Absolute and relative reduction of FL throughput for cross-country system configuration and 40% spectrum overlap